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SEASONAL FLIGHT PATTERNS OF BARK AND AMBROSIA BEETLES (COLEOPTERA: SCOLYTIDAE) IN NORTHEASTERN OREGON

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Abstract.—The abundance and phenology of scolytid beetles collected in multiple-funnel traps baited with the Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopkins) pheromones frontalin, seudenol, MCOL, and ethanol in NE Oregon are reported. Other than *D. pseudotsugae*, *Dendroctonus ponderosae* Hopkins, and *Dendroctonus rufipennis* (Kirby), a total of 17,612 beetles from 44 species were collected between 5 May and 21 Sep 1993. *Dendroctonus brevicomis* LeConte and *Hylastes nigrinus* (Mannerheim) were most abundant (comprising 44.5% and 31.7% of the total, respectively), followed by *Pityophthorus confertus* Swaine (8.5%), *Dendroctonus valens* LeConte (4.2%), *Hylastes longicollis* Swaine (3.4%), and *Hylastes ruber* Swaine (2.7%). Most species were rare; the combined number of individuals of the 26 least common species comprised <1% of the total. *Pityophthorus deletus* LeConte and *Pityophthorus grandis* Blackman are reported from Oregon for the first time. Flight activity for most species began after a seasonal increase in temperature in mid-May and subsided by late July. Seasonal flight patterns are shown for the 14 most abundant species. It is unknown how each species was affected by the lure, but ethanol may have been an important attractant for many species.

Key Words.—Insecta; Scolytidae; Oregon; Phenology; Pheromones; Trapping

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The Scolytidae are a diverse group of beetles that live primarily within phloem and cambium (bark beetles) or xylem (ambrosia beetles) tissues of freshly dead, dying, physiologically stressed, or sometimes healthy trees (Rudinsky 1962, Furniss & Carolin 1977). Scolytids contribute to forest processes such as providing food for insectivorous birds (Knight 1958, Otvos 1965), facilitating the decomposition of dying trees (Schowalter et al. 1992), vectoring tree pathogens (Graham 1967, Hessburg et al. 1995), and providing fuel for wildfires (Geizler et al. 1980), thus influencing the structure and species composition of forest communities (Schmid & Hinds 1974, Veblan et al. 1991). Although the biology of some economically important species is well known (Stark & Dahlsten 1970, Thatcher et al. 1980, Wood, S. L. 1982, Christiansen & Bakke 1988, Raffa 1988), considerably less is known about the distribution and life-history of other species. Chamberlin (1917) first summarized the scolytids found in Oregon. S. L. Wood (1982) and Furniss et al. (1992) subsequently added a number of species to those identified in the earlier report. However, distribution records for most species are from a small number of localities. Information on the flight behavior and seasonal distribution of some scolytids in western Oregon has been provided by Rudinsky

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& Daterman (1964), Daterman et al. (1965), and Zethner-Møller & Rudinsky (1967).

Pheromones and host-tree derived chemicals are useful for studying the biology and behavior of some scolytid species. For example, pheromones have been used to identify communication patterns regulating host-tree colonization, mate-finding, and reproduction of various species (Furniss et al. 1972, Wood & Bedard 1977, Birch 1978, Wood, D. L. 1982). This understanding has led to the development of pheromone applications to reduce damage caused by pest species (Bakke 1982, McGregor et al. 1984, Ross & Daterman 1994, 1995). However, because individual pheromones, or their combinations, are generally narrow in specificity, most studies have been restricted to only one or a few species. In contrast, chemicals released from stressed or decaying trees, such as ethanol (Kimmerer & Kozlowski 1982, Byers 1992, Lindelow et al. 1992, Kelsey 1994) and terpenes (Vité & Gara 1962), are attractive to a variety of scolytids (Rudinsky 1966, Moeck 1970, 1971, Moeck et al. 1981, Montgomery & Wargo 1983, Klimetzek et al. 1986, Chenier & Philogene 1989, Schroeder & Lindelow 1989, Byers 1992). As a result, studies using traps baited with these chemicals have added significantly to our understanding of scolytid distribution and activity patterns (Roling & Kearby 1975, Turnbow & Franklin 1980, Atkinson et al. 1988).

Life-history information for many scolytid species found in Oregon is lacking, particularly east of the Cascade Mountain Range. This study describes the seasonal flight patterns of scolytids caught in funnel traps baited with Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopkins) pheromones in the Blue Mountains of NE Oregon. Of the pheromones used, frontalin (Pitman & Vité 1970), seudenol (Vité et al. 1972) and MCOL (Libbey et al. 1983) are released by the female beetle during the initial stages of tree colonization, and ethanol can be released by either sex, the host tree, or by associated microorganisms (Pitman et al. 1975). Data presented here were obtained by sorting scolytids from a subset of trap samples from a study designed to test the effectiveness of attractant-baited traps for area-wide management of Douglas-fir beetle populations (Ross & Daterman 1997).

Methods and Materials

Traps were placed within the NE portion of the Wallowa Valley Ranger District of the Wallowa-Whitman National Forest in NE Oregon. All traps were located at elevations between 1470 and 1690 m. Forests in the area are mixed conifer, comprised largely of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), grand fir (*Abies grandis* (Dougl.) Lindl.), western larch (*Larix occidentalis* Nutt.) and lodgepole pine (*Pinus contorta* Dougl.), with scattered Engelmann spruce (*Picea engelmannii* Parry ex Engelm.) and alpine fir (*Abies lasiocarpa* (Hook.) Nutt.). Forest structure in the area is variable reflecting a history of natural and human-caused disturbances. Temperature data for the trapping period were obtained from a weather station located at 1281 m elevation approximately 26 km from the trap sites.

Within the study area, three 259-ha plots were established for trapping (Ross & Daterman 1997). Approximate latitude and longitude for each plot were 45°51′ N/117°07′ W, 45°50′ N/117°03′ W, and 45°44′ N/116°52′ W. Within each plot, 12–14 trap sites were chosen that were a minimum of 0.25 km apart. Three traps, spaced approximately 10 m apart, were located at each site. Traps were placed in clearings or young stands away from potential scolytid breeding material. Due to disturbance from cattle and/or wildlife, some traps had missing samples on at least one occasion during the study. Twenty-one traps without missing samples (seven from each plot) were identified for analysis. No site was represented by more than one trap.

The traps were a 16-unit multiple-funnel type (Lindgren 1983) suspended from an eight-foot metal pole, with a DDVP-impregnated piece of plastic in the collecting cup to kill insects. Each trap was baited with 250 ul of frontalin in an eppendorf vial, 200 mg of MCOL in a bubble capsule, and 15 ml of ethanol in a plastic pouch (Phero Tech Inc., Delta, BC, Canada). Each trap also contained either 400 mg of frontalin and 200 mg of seudenol, or 200 mg of frontalin and 100 mg of seudenol, in 5% PVC formulations (Daterman 1974). All formulations released pheromone or kairomone throughout the trapping period (DWR, unpublished data).

Traps were deployed by 5 May 1993. Samples were collected on or within one day of the following dates: 18 and 25 May; 7, 22 and 29 Jun; 6, 14 and 27 Jul; 10, 18 and 24 Aug; 3 and 21 Sep 1993. Samples were initially sorted only for *Dendroctonus pseudotsugae* and selected predators. However, because *Dendroctonus ponderosae* Hopkins and *Dendroctonus rufipennis* (Kirby) look similar to *D. pseudotsugae*, and were relatively rare in the samples, they were probably combined with *D. pseudotsugae* during the sorting process. Remaining scolytids were removed from the samples at a later date for the present study. Species were identified and compared to reference material within the USDA Forest Service Hopkins Forest Insect Collection. Voucher specimens from this study were deposited in the Oregon State University Systematic Entomology Laboratory Collection.

Results and Discussion

Other than *D. pseudotsugae*, *D. ponderosae* and *D. rufipennis*, a total of 17,612 scolytid beetles within 44 species were identified from the 21 funnel traps (Table 1). *Dendroctonus brevicomis* LeConte and *Hylastes nigrinus* (Mannerheim) dominated the samples numerically, comprising 44.5% and 31.7% of the total, respectively. All other species were much less common, with *Pityophthorus confertus* Swaine (8.5%), *Dendroctonus valens* LeConte (4.2%), *Hylastes longicollis* Swaine (3.1%), and *Hylastes ruber* Swaine (2.7%) being the next most abundant species. Overall, most species were relatively rare; the 26 least common species collectively comprised <1% of the total. Specimens of *Pityophthorus deletus* LeConte and *Pityophthorus grandis* Blackman represent first records of occurrence for Oregon. For *P. deletus*, this record fills a distributional gap, with previous collections in British Columbia, Idaho and California, and the known distribution of *P. grandis* is extended northward from California. All species collected are known to utilize coniferous trees present within the study area (Bright & Stark 1973, Wood, S.L. 1982).

Flight patterns of many species showed a strong seasonal trend, with flight initiation corresponding to the first warm days of spring. Temperatures showed a marked seasonal increase on 10 May, rising from a previous two-week average of 6.7° C, to 24° C by 12 May (Fig. 1). *Hylurgops porosus* (LeConte), *Hylurgops*

Table 1. Number of scolytid beetles collected in funnel traps baited with frontalin, seudenol, MCOL and ethanol between 5 May and 21 Sep 1993 in NE Oregon.

Taxon	Number trapped
Hylastini	
Hylurgops porosus (LeConte)	54
Hylurgops reticulatus Wood	29
Hylurgops subcostulatus (Mannerheim)	90
Hylastes gracilis LeConte	4
Hylastes longicollis Swaine	547
Hylastes macer LeConte	110
Hylastes nigrinus (Mannerheim)	5583
Hylastes ruber Swaine	483
Hylastes tenuis Eichoff	2
Tomicini	
Pseudohylesinus dispar Blackman	8
Pseudohylesinus nebulosus (LeConte)	153
Pseudohylesinus granulatus (LeConte)	3
Dendroctonus brevicomis LeConte	7830
Dendroctonus ponderosae Hopkins	—[a]
Dendroctonus pseudotsugae Hopkins	—[a]
Dendroctonus rufipennis (Kirby)	—[a]
Dendroctonus valens LeConte	745
Phloeotribini	
Carphoborus intermedius Wood	1
Phloeotribus lecontei Schedl	3
Polygraphini	
Polygraphus rufipennis (Kirby)	17
Scolytini	
Scolytus laricis Blackman	5
Scolytus opacus Blackman	28
Scolytus piceae (Swaine)	3
Scolytus tsugae (Swaine)	3
Scolytus unispinosus LeConte	83
Scolytus ventralis LeConte	6
Dryocoetini	
Dryocoetes sechelti Swaine	1
Ipini	
Pityogenes carinulatus (LeConte)	49
Pityogenes fossifrons (LeConte)	2
Pityogenes knechteli Swaine	1
Pityokteines elegans Swaine	5
Pityokteines ornatus (Swaine)	2
Orthotomicus caelatus (Eichhoff)	8
Ips emarginatus (LeConte)	1
Ips latidens (LeConte)	2
Ips pini (Say)	24
Xyloterini	
Trypodendron lineatum (Olivier)	2
Corthylini	
Pityophthorus confertus Swaine	1490
Pityophthorus confinis LeConte	31
Pityophthorus deletus LeConte	1
Pityophthorus grandis Blackman	2
Pityophthorus nitidulus (Mannerheim)	4
Gnathotrichus retuses (LeConte)	192
Gnathotrichus sulcatus (LeConte)	5
Total number of beetles	17,612

[a] *D. ponderosae* and *D. rufipennis* were probably grouped with *D. pseudotsugae* during the sorting process. Data for these three species are presented elsewhere (Ross and Daterman 1997).

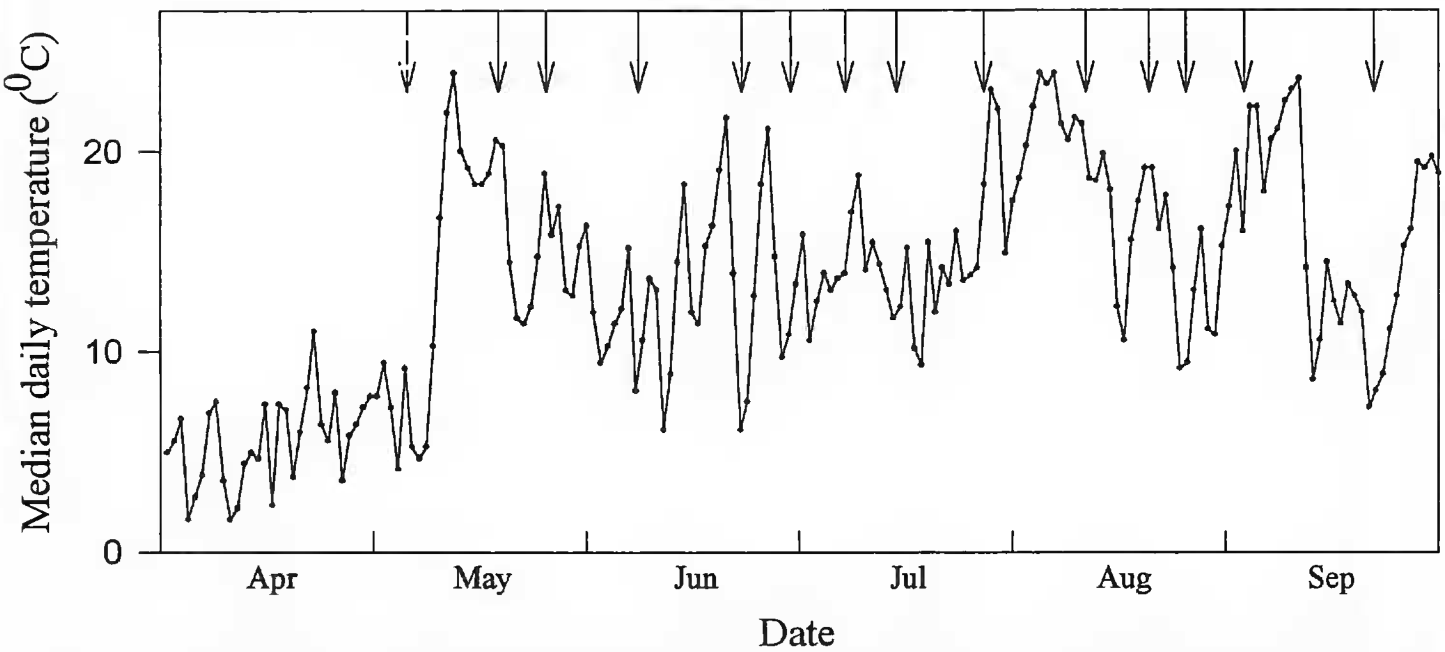

Figure 1. Median daily temperature near the study site. Solid arrows indicate sample collection dates and dashed arrow shows date traps were placed in the field.

subcostulatus (Mannerheim), *Hylastes macer* LeConte, *H. nigrinus*, *Pseudohylesinus nebulosus* (LeConte), *Pityogenes carinulatus* (LeConte), and *Gnathotrichus retusus* (LeConte) were collected at or near their greatest abundance during one of the two sampling periods in May (Fig. 2). Similar early season activity patterns were reported by Daterman et al. (1965), who found a maximum daily temperature of 14° C necessary to initiate flight for most of the scolytid species they collected in western Oregon. Although temperatures were consistently low prior to the time traps were set out, some scolytids may have been flying earlier. For example, *P. nebulosus* was most abundant on the first sample date, with a precipitous drop in activity thereafter (Fig. 2), and was previously found to be one of the earliest species to fly in other regions (Walters & McMullen 1956, Daterman et al. 1965). *Pityophthorus confinus* LeConte was most abundant in the 7 June samples, while five species (*H. longicollis*, *H. ruber*, *D. brevicomis*, *D. valens*, *Scolytus unispinosus* LeConte) were most abundant in the 22 or 29 June samples (Fig. 2). Daterman et al. (1965) also found *H. ruber* and *S. unispinosus* to be most active slightly later than other species, suggesting their need for higher temperatures to initiate flight. Although most species showed a single peak in activity, *P. confertus* was abundant in May, June and July, and *D. brevicomis* and *D. valens* were trapped in relatively large numbers into September. The individuals collected during mid- to late season were likely re-emergent parent adults searching for new breeding substrates or newly emerging early-season brood adults (Miller & Keen 1960, Stark & Dahlsten 1970). For most other species, flight activity had decreased by 14 July. Daterman et al. (1965) also found diminished activity levels by the end of July.

More individuals of many species were collected than expected by chance, suggesting that these species were attracted to the lure rather than being passively intercepted by the traps. However, because lure composition was not experimentally manipulated, it is not possible to determine which components were attractive to each species. Of the attractants used, frontalin is known to be a component of the aggregation pheromone of *D. brevicomis* and may have contributed to its attraction (Bedard et al. 1980). Ethanol has been shown to be a strong attractant

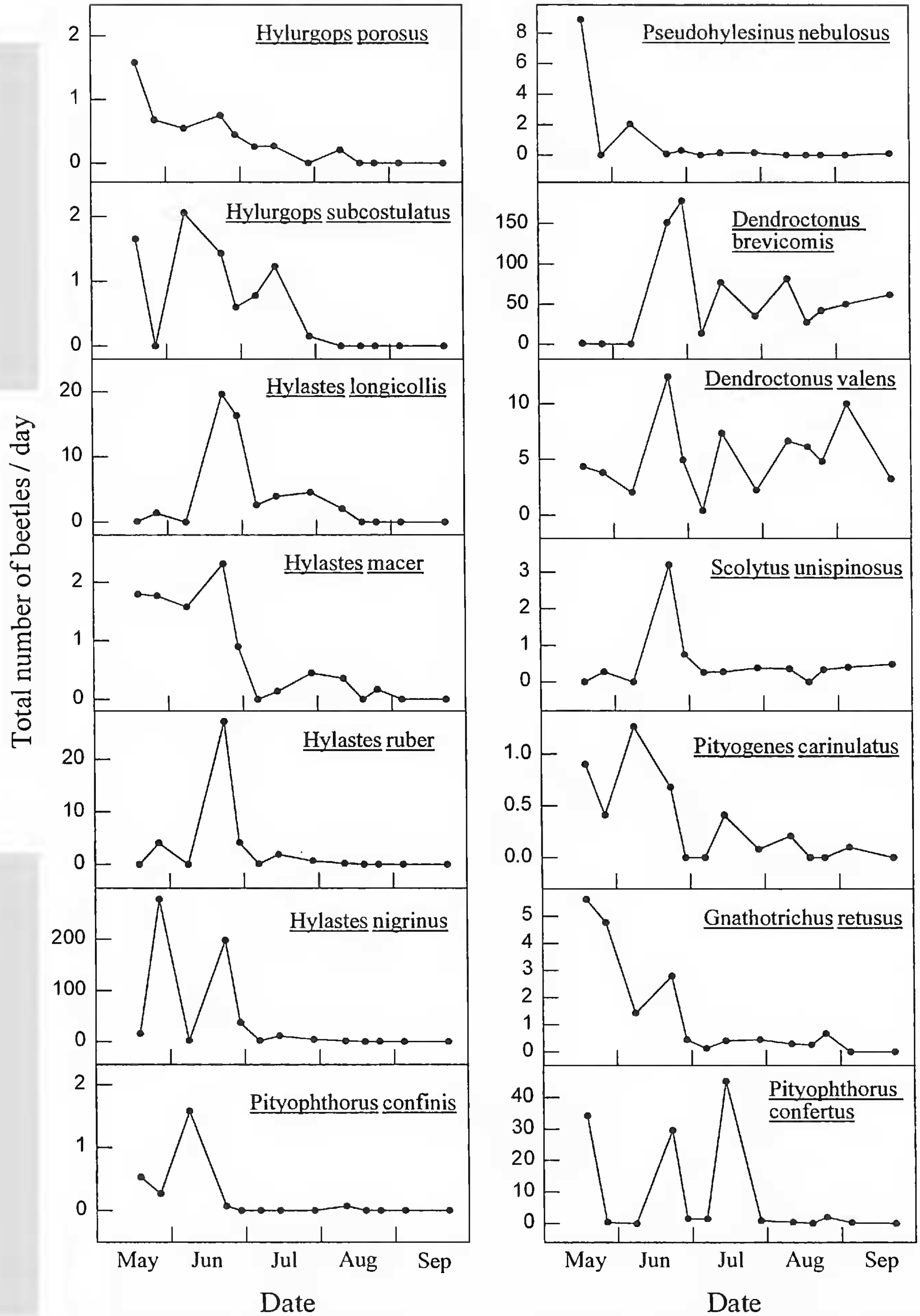

Figure 2. Seasonal flight patterns for the 14 most frequently trapped scolytid species within the study area.

for ambrosia beetles, such as *G. retusus*, (Moeck 1970, 1971, Roling & Kearby 1975, Turnbow & Franklin 1980, Kelsey 1994) as well as for *H. nigrinus* (Witcosky et al. 1987). Ethanol was possibly responsible for the attraction of some of the abundant scolytids, because only *D. brevicomis* is known to be attracted to any of the Douglas-fir beetle pheromones used in the lure. Trapping in the same area in 1994 with frontalin and seudenol lures captured very few scolytids other than *D. pseudotsugae* (DWR, unpublished data), further suggesting the importance of ethanol as an attractant.

The number of scolytids collected in each trap varied greatly even though the surrounding forests were similar in elevation and tree composition. For most species, a relatively small number of traps caught a large proportion of the total number of individuals. For example, 95.0% of *P. confertus* were from one trap, 69.8% of *H. nigrinus* were collected from one trap and 87.3% from two traps, 86.5% of *D. brevicomis* were collected from four traps, 75.4% of *D. valens* were collected from three traps and 81.4% of *H. longicollis* were collected from four traps. Although the numbers collected were concentrated in a few traps for these species, they occurred frequently, being collected in 11, 20, 19, 20, and 12 of the 21 traps, respectively. In contrast, many species were only collected in a few traps. For example, 16 species were caught in only one or two traps and 17 other species were collected in five traps or less.

This study has identified a large number of bark and ambrosia beetles captured in multiple-funnel traps baited with Douglas-fir beetle pheromones from a poorly studied part of Oregon, and has shown seasonal flight patterns for many of these species. It is not known which components of the lure were most attractive to the beetles, but ethanol may have been important because it is a by-product of tree decomposition as well as a pheromone. Because many species are patchily distributed across the landscape, a large number of traps in various forest stand types will be necessary to adequately sample scolytid communities.

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